

REMARKS

Reconsideration of the pending application is respectfully requested in view of the foregoing amendments and the following remarks.

Status of the Application

Claims 1-14 are currently pending. No amendments are presented in this response.

Summary of the Office Action

Claims 1-14 are rejected under 35 U.S.C. § 103(a) as obvious over EP 1 176 646 A1 (Graetzel et al.) in view of Van der Auweraer et al. (J. Phys. Chem. 1993, 97, 8808-11), with supporting evidence provided by Thelakkat (Macromol. Mater. Eng. 2002, 287, 442-61).

Claims 1, 3-8 and 10-14 are rejected under 35 U.S.C. § 103(a) as being obvious over Graetzel et al. in view of Shirota et al. (J. Mater. Chem., 2000, 10, 1-25), with supporting evidence provided by Thelakkat.

Discussion

Aspects of the present invention are predicated in part on the following discovery, described at pages 4-5 of the application as filed:

It has been surprisingly found that by rendering tris-1,3,5-amino-phenylbenzene in a cationic form, hole transporting properties were exhibited which rendered them compatible with solid state photovoltaic cell configurations, e.g., with a microporous titanium dioxide layer.

The Office Action asserts that Graetzel et al. does not disclose hole-transport compounds as described in claims 1, 2, 7-9 and 14, but Van der Auweraer et al. teach a species described by the formula of claims 1, 7, 8 and 14, and the first listed species set forth in claims 2 and 9. The substitution is based on the Van der Auweraer species having comparable or superior hole mobility to other known hole transport materials. Further, the Office Action discounts the cationic form limitation of claims 1-7, as the presence of a hole in this hole transport compound allegedly inherently imparts a positive charge to the molecule. The inherency argument is purportedly supported by a passage from Van der Auweraer which references a “one electron oxidation-reduction process” and Thelakkat

which describes the triarylamine unit's "ability to transport positive charge center via the radical cation species."

In response, Applicants submit that the hole-transporting compounds investigated by Van der Auweraer are non-ionized compounds, and one skilled in the art would not appreciate that such compounds would be inherently cationic. Indeed were the cationic form of these Van der Auweraer compounds to be inherently present (i.e., positive charges), as suggested in the Office Action, the excellent hole transport observed with these compounds would not be possible. This is because the hole transport would be inhibited by the positive charges due to the compound being inherently cationic repelling the holes, it being an elementary law of physics that like charges repel.

A 1,3,5-tris-aminophenyl-benzene compound in its cationic form means that non-ionized 1,3,5-tris-aminophenyl-benzene compounds have been converted into positively charged 1,3,5-tris-aminophenyl-benzene compounds as indicated by changed absorption properties. In the examples, 1,3,5-tris-aminophenyl-benzene compounds were oxidized with N(p-C₆H₄Br)₃SbCl₆, with sufficient N(p-C₆H₄Br)₃SbCl₆ being present to ensure that the oxidation went to completion to the respective trications as determined spectrophotometrically. *See page 23, lines 13-28, of the application as filed.*

One skilled in the art would expect these positive charges to inhibit hole transport due to like charges repelling one another. Therefore, it is totally unexpected that 1,3,5-tris-amino-phenyl-benzene compounds in their cationic form can be used as efficient hole transporting media in photovoltaic cells with titanium dioxide as the electron-transporting medium than the 1,3,5-tris-aminophenyl-benzene compounds themselves.

For at least these reasons, Applicants respectfully submit that claims 1-7 are not rendered obvious by the asserted combination of references. That the compound is cationic flies in the face of knowledge possessed by those skilled in the art in the field of organic hole-transporting compounds.

Further, the teaching of Graetzel is limited to teaching a solid state p-n heterojunction by combining an inorganic n-type semiconductor with an efficient p-type organic hole-transporting material. There is no suggestion in either Graetzel or Van der Auweraer that

would motivate one skilled in the art to modify an already efficient hole-transporting compound, and certainly not in a direction which one skilled in the art would expect would lead to a strong deterioration in hole-transporting properties (e.g., by providing a cationic compound).

Applicants thus submit that the inventions of claims 1-14 are patentable over the combination of prior art asserted in the Office Action.

The second rejection, in which claims 1, 3-8 and 10-14 are rejected, fairs no better. Again, the Office Action admits that Graetzel fails to disclose the claimed hole-transport compounds, but that the compounds taught by Shirota may be substituted therein.

In response, Applicants submit that the hole-transporting compounds investigated by Shirota are non-ionized compounds, and one skilled in the art would not appreciate that such compounds would be inherently cationic. Indeed were the cationic form of these Shirota compounds to be inherently present (i.e., positive charges), as suggested in the Office Action, the excellent hole transport observed with these compounds would not be possible. This is because the hole transport would be inhibited by the positive charges due to the compound being inherently cationic repelling the holes, it being an elementary law of physics that like charges repel.

A 1,3,5-tris-aminophenyl-benzene compound in its cationic form means that non-ionized 1,3,5-tris-aminophenyl-benzene compounds have been converted into positively charged 1,3,5-tris-aminophenyl-benzene compounds as indicated by changed absorption properties. In the examples, 1,3,5-tris-aminophenyl-benzene compounds were oxidized with N(p-C₆H₄Br)₃SbCl₆, with sufficient N(p-C₆H₄Br)₃SbCl₆ being present to ensure that the oxidation went to completion to the respective trications as determined spectrophotometrically. *See page 23, lines 13-28, of the application as filed.*

One skilled in the art would expect these positive charges to inhibit hole transport due to like charges repelling one another. Therefore, it is totally unexpected that 1,3,5-tris-amino-phenyl-benzene compounds in their cationic form can be used as efficient hole transporting media in photovoltaic cells with titanium dioxide as the electron-transporting medium than the 1,3,5-tris-aminophenyl-benzene compounds themselves.

For at least these reasons, Applicants respectfully submit that claims 1-3 and 7 are not rendered obvious by the asserted combination of references. That the compound is cationic flies in the face of knowledge possessed by those skilled in the art in the field of organic hole-transporting compounds.

Further, the teaching of Graetzel is limited to teaching a solid state p-n heterojunction by combining an inorganic n-type semiconductor with an efficient p-type organic hole-transporting material. There is no suggestion in either Graetzel or Shirota that would motivate one skilled in the art to modify an already efficient hole-transporting compound, and certainly not in a direction which one skilled in the art would expect would lead to a strong deterioration in hole-transporting properties (e.g., by providing a cationic compound).

Applicants thus submit that the inventions of claims 1, 3-8 and 10-14 are patentable over the combination of prior art asserted in the Office Action.

Conclusion

As Applicants believe the application is in proper condition for allowance, the examiner is respectfully requested to pass the application to issue. If, in the opinion of the Examiner, a telephone conference would expedite the prosecution of the subject application, the Examiner is invited to call the undersigned attorney.

Respectfully submitted,

/Christopher T. Griffith/

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